VII. "On the progressive Paralysis of the different Classes of Nerve Cells in the Superior Cervical Ganglion." By J. N. LANGLEY, F.R.S., Fellow and Lecturer of Trinity College, and W. LEE DICKINSON, M.R.C.P., Caius College, Cambridge. Received March 15, 1890.

It is well known that by stimulating the sympathetic nerve in the neck the following effects can be produced:—(1) Retraction of the nictitating membrane; (2) protrusion of the eyeball and opening of the eye; (3) turning the eye, if previous to stimulation the optic axis is directed nasally, so that the optic axis is directed straight forwards, or it may be forwards and a little outwards; (4) dilation of the pupil; (5) constriction of the small arteries of the ear, conjunctiva, and of various other parts of the head; (6) in the dog, dilation of the small arteries of the gums, lips, and of some other parts of the head; (7) secretion of saliva.

We have shown that the superior cervical ganglion contains nerve cells, interpolated in the course of the nerve fibres concerned in producing all the above effects, and, further, that these nerve cells are readily paralysed by nicotin.* In this paper we consider the question whether the nerve cells are paralysed simultaneously or in a definite order. That different classes of nerve cells are in some cases unequally affected by nicotin has been already shown by one of us (L., *op. cit.*), in so far that in the cat the secretory nerve cells on the course of the cervical sympathetic are more readily paralysed than the secretory nerve cells on the course of the chorda tympani; that in the dog the reverse is the case; and, lastly, that the nerve cells on the course of the secretory fibres of the chorda tympani are paralysed before those on the course of its vaso-dilator fibres.

The method employed has been to inject nicotin into a vein, (*a*) in successive doses, the first dose being rather less than that required to produce complete paralysis of the cervical sympathetic, and to note the order in which the effects normally produced by stimulating the sympathetic disappear; (*b*) in quantities sufficient to cause complete paralysis of the cervical sympathetic, and by stimulating it at short intervals to note the order of recovery of the normal effects of such stimulation.

Of course, by injecting the alkaloid into the blood, the peripheral nerve endings, as well as the nerve cells of the superior cervical ganglion, are exposed to its action; but since, as we have shown

* Langley and Dickinson, 'Roy. Soc. Proc.,' vol. 46, 1889, p. 423; Langley, 'Journal of Physiology,' vol. 11, 1890, p. 146.

(*op. cit.*), even large doses of nicotin* do not prevent the normal sympathetic effect from being obtained on stimulating peripherally of the superior cervical ganglion; any absence of the normal effect of stimulating the sympathetic in the neck which may be caused by a small dose of nicotin must be due to the action of the alkaloid on the nerve cells of the ganglion.

The method of injecting nicotin into a blood vessel is preferable to that of applying dilute nicotin to the ganglion itself (although this has the advantage of limiting the effect to the ganglion), because of the difficulty of applying the nicotin in such a way as to make certain that equal amounts reach all the nerve cells; by the latter method it might be possible for the external cells of the ganglion to be paralysed and the internal cells to have escaped paralysis.

In the course of our experiments we have naturally had frequent occasion to observe the effect of stimulating the sympathetic upon the blood supply of the lips and gums. It will be convenient to discuss this action before proceeding to the more immediate object of our experiments.

Effect of Stimulating the Sympathetic upon the Bucco-labial Region.—The discovery in the sympathetic of the dog of vaso-dilator fibres for the lips, gums, and of some other parts of the head is due to Dastre and Morat.† The whole region in which dilation is produced they call the bucco-facial region; this includes the mucous membrane of the nose, hard palate, of the gums, lips, and the neighbouring cutaneous regions. On the other hand, the same stimulus produces constriction of the small arteries in the epiglottis, tonsils, and soft palate. Bochefontaine and Vulpian‡ observed, that sometimes the dilation was preceded by a constriction. Dastre and Morat§ later found a similar constriction; they state that it occurs only with a certain strength of current, which is a little less than that required to produce primary dilation, so that, when electric shocks cause constriction before the dilation, no effect is produced if the shocks are made a little weaker, and primary dilation is produced if they are made a little stronger.

In our experiments, the variation in the strength of the shocks

* In a recent experiment upon a rabbit 1450 mgm. of nicotin were injected into a vein without causing the heart to stop. Stimulation of the filament running from the superior cervical ganglion to the internal carotid, *i.e.*, stimulation of the sympathetic peripherally of the ganglion, still caused dilation of the pupil. As the experiments in this paper show, 5 to 10 mgm. of nicotin are sufficient to prevent stimulation of the sympathetic in the neck, *i.e.*, of the sympathetic centrally of the ganglion, from producing any effect on the pupil.

† Dastre and Morat, 'Comptes Rendus de l'Acad. des Sciences,' vol. 91, 1880, pp. 393 and 441.

‡ Bochefontaine and Vulpian, 'Soc. de Biologie,' 1880, p. 319.

§ Dastre and Morat, 'Le Système Nerveux Vaso-Moteur' (Paris), 1884, p. 180.

capable of producing primary contraction was much greater than that given by Dastre and Morat. On gradually increasing the strength of the shocks we find with minimal shocks a slight paling of the lips and gums, which only slowly disappears, so that the original pinkish state of the mucous membrane is not regained for one to two minutes after the end of the stimulation. As the shocks are gradually increased in strength the paling becomes more marked, and the after-paling of less duration; with a certain increase in the strength of shocks, the paling continues for a short time after the stimulation, and then gives way to a slight flushing; with further increase, the duration of the after-paling diminishes and the after-flush increases, so that soon the pallor gives way, even during the continuance of the stimulation, to intense flushing. After this, a slight further increase in the strength of the shocks causes primary flushing. Marked flushing is first produced in the anterior part of the lips and gums; a stronger current is required to produce it in the posterior part of the lips and gums and in the hard palate.

We have found a primary pallor with very considerable variation in the strength of the current. Thus in one case primary flushing was first obtained with the index of the secondary coil at 9 cm. from the primary coil; with the secondary coil at 18 cm., a slight, though distinct, pallor was produced; moreover, the after-flush produced by the stronger stimulus was considerably shortened by applying to the nerve the weaker stimulus. In another case the secondary coil was gradually shifted in successive stimulations from 20 cm. to 6 cm. distance from the primary. In all the first effect was pallor; with the weaker stimuli this alone was obtained.* The shocks with the secondary coil at 6 cm. could scarcely be borne on the tongue; with the secondary coil at about 15 cm. they could not be felt on the tongue.

Although some of the results which we have just mentioned do not agree with those of Dastre and Morat, we wish to point out that they do not conflict with, but rather confirm, the main contention of these observers, viz., that the sympathetic contains both vaso-constrictor and vaso-dilator fibres for the bucco-labial region.

And from the unequal effects of a moderately strong stimulus on the different parts of the bucco-facial region, we may conclude that the proportion of constrictor and dilator fibres for the different parts

* Laffont ('Soc. de Biologie,' 1880, p. 341), on stimulating the uncut vago-sympathetic in an atropinised dog, found with all strengths of stimulation primary constriction followed by dilation, the primary constriction being briefer the stronger the stimulation. Apparently, however, the paralysis of the inhibitory fibres of the vagus by the atropin given was assumed, and actual observation on the point omitted; and Dastre ('Soc. de Biologie,' 1880, p. 348) attributes the previous pallor obtained on stimulating the sympathetic to a slowing or cessation of the heart-beat.

of the region is not the same; and from the unequal effects on different dogs we may probably conclude that the proportion of the two kinds of nerve fibres varies somewhat in different individuals, although it is possible that the results on which this conclusion is based may be caused by a temporary variation in the condition of the animal, for example, in the amount of anæsthetic given.

It was noticed by Bochefontaine and Vulpian and also by Dastre and Morat that in the cat and rabbit pallor, and not flushing, of the bucco-labial region is caused by stimulating the cervical sympathetic. Like these observers, we have not seen primary flushing with any strength of stimulus; the pallor is marked, except when, for any reason, the gums and lips are already pale; as a rule there is no marked after-flush, but the mucous membrane slowly regains its normal tint. On repeated stimulation of the sympathetic the bucco-labial region remains pale and shows very little alteration. In the course of our experiments upon the dog, we had occasionally seen a slight paling or flushing in the lips and gums on the side opposite to that on which the sympathetic was stimulated; in the cat and rabbit we have paid more attention to this effect, and we find that in these animals, stimulation of the sympathetic produces a bilateral effect. The pallor on the opposite side to that on which the nerve is stimulated is greater in the rabbit than in the cat, and is more obvious in the gum of the anterior part of the lower jaw than elsewhere. The degree of the pallor on the opposite side varies considerably in different individuals. Occasionally in the rabbit the pallor is complete on both sides, but in most cases it is much more marked on the side on which the nerve is stimulated. The bilateral action occurs with either sympathetic, although it may be more marked with one sympathetic than with the other; it occurs with all strengths of currents that produce any effect; it is best seen at the beginning of an experiment, for after repeated stimulation of the sympathetic the paling on the opposite side becomes less distinct, and it is much better seen in the anterior than in the posterior part of the lips and gums. In the rabbit a little care must be taken not to stretch the lips too much during the experiment, since this of itself may cause some pallor in the gums. We have also seen some bilateral pallor in the tongue, especially in the tip on stimulation of one sympathetic; but we have paid attention to this in a few experiments only.

Experiment I.

Rabbit (C. p. 34). Chloral. Chloroform and ether. Sec. coil at 9 gives shocks rather weak to tongue.

12.13. Tie and cut left sympathetic (separated from depressor) in middle of neck.

Stim. sy., $c = 9$, for 20 secs.; bilateral pallor in upper and lower lips; in

the anterior part of the lower lip the pallor is nearly equal on the two sides, in the upper lip the paling on the opposite side to that stimulated is distinct, though slight.

12.30. Cut right sympathetic and both vagi at the level of the upper part of the larynx.

Stim. sy., $c = 9$, for 20 secs. Bilateral pallor in upper and lower lip as before.

We may mention that, notwithstanding the difference in the dog on the one hand, and the cat and rabbit on the other, in the effect of stimulating the sympathetic on the bucco-facial region, a small dose of nicotin causes in each case a primary flushing in the region; in the dog the flushing is most intense, in the cat and rabbit it is comparatively slight, and may be very brief. Of this we shall have more to say in a later paper on the general action of nicotin.

Having thus given the effects which may be expected to follow stimulation of the sympathetic in the neck, we may now proceed to consider the order in which they cease on injecting into the blood-vessels small doses of nicotin. Our experiments have been made upon the rabbit, cat, and dog. As a rule, in any one experiment, a few only of the effects can be accurately observed. Thus, in order to observe with certainty a slight dilation of the pupil, it may be necessary to pull back the eyelids, in which case a slight movement of the eyelids, if such were caused by the stimulation, might escape observation. It has appeared to us that the effect of stimulating the sympathetic on the movements of the eyelids, the eye, and especially on the nictitating membrane, diminishes with the amount of the anæsthetic given. At any rate, in the rabbit and cat we have occasionally observed so little effect on the nictitating membrane to be caused by stimulating the sympathetic, that no certain conclusion could be drawn from the absence of such effect after giving nicotin.

It is necessary, then, to note carefully to what extent the various effects which may be produced by stimulating the sympathetic are in fact produced, immediately before the introduction of nicotin.

In nearly all cases the sympathetic in the neck was ligatured and cut. This was done, in the first place, to avoid reflex action, and, secondly, in the hope that, since section of the sympathetic commonly produces the opposite effects of stimulation, the effects of stimulation might thereby become more marked. It has often been noticed that section of the sympathetic produces a transient slight effect only, or even none; this was the case in most of our experiments, so that at the time of injecting nicotin, the ears and pupils on the two sides were alike, occasionally the ear being flushed but the pupil not contracted, or the pupil being a little contracted but the ear not flushed, on the cut side.

We have mentioned above that we have sometimes made observa-

tions on the progressive paralysis of the different sympathetic actions by giving a dose insufficient to paralyse them all, and sometimes by giving a larger dose and noting the progressive recovery. The former method is more troublesome, but brings out greater differences than the latter. The order of recovery is inversely as the order of primary paralysis.

The Rabbit.—As anæsthetics we have used chloral, and afterwards chloroform and ether, or, more rarely, chloral and morphia. In the anæsthetised animal the eyes are directed forward, and the pupils are rather large; after nicotin has been injected the eyes are directed forward, and the pupils are in nearly all cases smaller than previously. With regard to the relative time of paralysis of the secretory fibres in the cervical sympathetic, we have made no observations in the rabbit.

The easiest comparison to make is that between one of the changes which occur in the eye and the pallor of the ear. In the following experiment the comparison is made between the dilation of the pupil and the constriction of the central artery of the ear. The difference between the ease and duration of the paralysis of these two actions, though always appreciable, is nevertheless sometimes slight. The experiment we quote shows, perhaps, the maximum difference which we have observed.

Experiment II.

Rabbit (C. p. 7). Chloral given. Right sympathetic tied and cut in middle of the neck. Stimulation of the sympathetic with a weakish current ($c = 10$) produces dilation of the pupil and constriction of the arteries of the ear.

1.59. Inject 5 *mgm. nicotin.* into left jugular vein.
2.4. Stim. sy. for 20 secs., $c = 10$; no dilation of pupil, slight pallor of ear.
2.7. Stim. sy. for 20 secs., $c = 9$; no dilation of pupil, fair pallor of ear.
2.10. Stim. sy. for 30 secs., $c = 8$; no dilation of pupil, slight pallor of ear.
2.20. Stim. sy. for 20 secs., $c = 10$; no dilation of pupil, great pallor of ear.
2.27. Stim, sy. for 20 secs., $c = 10$; great dilation of pupil, and great pallor of ear.
2.35. Inject 5 *mgm. nicotin.*
2.40. Stim. sy. for 30 secs., $c = 10$; no dilation of pupil, slight pallor of ear.
3.12. Stim. sy. for 20 secs., $c = 10$; fair effect on both pupil and ear.
3.28. Stim. sy. for 10 secs., $c = 10$; nearly maximal dilation of pupil.
4.7. Inject 5 *mgm. nicotin.*
4.8. Stim. sy. for 10 secs., $c = 10$; great dilation of pupil and pallor of ear.
4.11. Inject 5 *mgm. nicotin.*
4.15. Stim. sy. for 10 secs., $c = 10$; great dilation of pupil and pallor of ear.
4.19. Inject 10 *mgm. nicotin.*
4.24. Stim. sy. for 30 secs., $c = 10$; no dilation of pupil, slight pallor of ear.
4.25. Stim. sy. for 60 secs., $c = 10$; no dilation of pupil, slight pallor of ear.
4.55. Stim. sy. for 60 secs., $c = 10$; no dilation of pupil, slight pallor of ear.
5.5. Stimulation of the sympathetic on the opposite side caused no dilation of the pupil, but a slight constriction of the vessels of the ear.

When we come to compare the effects more in detail, the difficulty is greater. This is especially the case in comparing the vaso-constrictor effects on the ear, mouth, and conjunctiva; for the pallor of all three, which often lasts for some time, and not for an equal time, as a secondary result of the nicotin makes it difficult to be certain of the beginning of vaso-constrictor action.

The movement of the nictitating membrane is more easily paralysed than the movement of the eyelids, and the latter is a little more easily paralysed than the dilation of the pupil. For the rest, the apparent order of ease of paralysis is vaso-constrictors of conjunctiva, vaso-constrictors of mouth, vaso-constrictors of ear; we say apparent order of paralysis, because we have instances from separate experiments, in which there has been, so far as could be judged, a simultaneous recovery in the dilation of the pupil and the pallor of the conjunctiva; pallor of conjunctiva and pallor of mouth; pallor of mouth and pallor of ear. The following experiments will illustrate the time differences observed:—

Experiment III.

Rabbit (C. p. 20). Chloral. Both cervical sympathetics ligatured and cut.

1.27. Inject into femoral vein 5 mgm. nicotin.

1.29. Stimulate left sympathetic; no effect.

1.31. Stimulate right sympathetic; no effect.

1.39. Stimulate left sympathetic; slight constriction of artery at base of ear, otherwise no effect.

1.40. Stimulate right sympathetic; slight constriction of artery at base of ear, otherwise no effect.

1.41. Stimulate left sympathetic for 60 secs.; fair constriction in artery of ear for about 45 secs.; no effect seen in lips.

1.46. Stimulate left sympathetic for 40 secs.; good constriction in artery of ear, gradual pallor of lower lip, chiefly on left side, but some on right. Slight after-flush.

1.50. Stimulate left sympathetic; slight dilation of pupil; conjunctiva already pale, shows no obvious change, but flushes a little when the stimulus has ceased. No movement of eyelid or nictitating membrane.

2.0. Stimulate right sympathetic. Marked pallor of conjunctiva, fair dilation of pupil; eye opens; no movement of nictitating membrane.

Experiment IV.

Rabbit (C. p. 27). Chloral. Right cervical sympathetic ligatured and cut. With secondary coil at 8 ($c = 8$) the shocks are distinctly felt on the tongue.

2.52. Inject 5 mgm. nicotin into crural vein.

3.20. Stim. sy., $c = 8$; usual effects, except that movement of eyelids very slight and movement of nictitating membrane only just perceptible.

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3.47. Stim. sy., good effects, except on nictitating membrane.

3.51. Inject 5 mgm. nicotin.

3.57. Stim. sy., 20 secs.; good constriction of artery of ear; slight pallor of mouth; no other effects observed.

3.59. Stim. sy., 30 secs.; good constriction of artery of ear; slight pallor of mouth and of conjunctiva, no effect on eyelid or nictitating membrane.
4.0. Stim. sy., 60 secs.; complete pallor of ear, slight pallor of conjunctiva, no dilation observed in pupil, but it is now a little larger than at 3.57.
4.5. Stim. sy., 10 secs.; fair pallor of conjunctiva, moderate dilation of pupil.
4.7. Stim. sy., 10 secs.; eyelids open slightly (previous to the stimulation the eyelids were pressed together).
4.13. Stim. sy., 30 secs.; pallor in lips and mouth is bilateral, but chiefly on the stimulated side.
4.19. Stim. sy., 30 secs., $c = 6$; eye opens and pupil dilates well, no movement of nictitating membrane.

The Cat.—In the cat, the secretory nerve cells of the superior cervical ganglion are paralysed before any others. After a small dose of nicotin (3 to 5 mgm.), stimulation of the cervical sympathetic causes, for a short time, no secretion of saliva, but still causes, or may cause, all the other effects normally seen as the result of the stimulation. The difference in the ease and duration of paralysis is in this case very striking. On the other hand, there is often very little difference in the ease of paralysis of the nerve cells of the superior cervical ganglion, which are connected with other classes of nerve fibres. There are some differences which are constant, but which vary very considerably in degree. In the following experiment, the difference between the time of paralysis of the vaso-motor effects on the ear and the dilator effect on the pupil is the maximum we have found.

Experiment V.

Cat (C. p. 24). Chloroform given, then morphia subcutaneously, and occasionally chloroform and ether. Cannula in the duct of the left sub-maxillary gland. Sympathetic in neck tied and cut on left side. Cut left chordo-lingual. The pupil is rather large; stimulation of the sympathetic with a weakish current ($c = 9$) causes the nictitating membrane to be drawn back, the eye to open, the pupil to dilate, the artery of the ear to constrict, and a secretion of saliva.

12.53. Inject into crural vein, 5 *mgm. nicotin.* The injection causes, amongst other effects, those described above as resulting from stimulation of the sympathetic.
1.0. Stim. sy., $c = 9$. Moderate opening of eye, dilation of pupil, and constriction artery of ear; no secretion.
1.5. Stim. sy., $c = 9$; effects as before.
1.13. Stim. sy., $c = 9$; secretion also.
1.18. Inject 5 *mgm. nicotin.*
1.28. Stim. sy., $c = 9$; no effect.
1.45. Stim. sy., $c = 9$; slight constriction artery of ear, no effect on pupil or on secretion.
1.50. Stim. sy., $c = 9$; constriction artery of ear, and slight dilation of pupil.
1.53. Stim. sy., $c = 9$; as before, and eye opens a little.
2.5. Stim. sy., $c = 9$; as before, but still no secretion.

The effect of the sympathetic upon the nictitating membrane is

paralysed less readily than the other effects of the sympathetic on the eye; in some experiments we have found a very considerable, in others a very slight, difference. Experiment V is an instance of the latter case.

Experiment VI.

Cat (C. p. 30). Chloroform. Right sympathetic ligatured and cut.
3.25. Inject into crural vein 4 *mgm. nicotin.*
3.38. Stim. sy., $c = 9$; all the usual effects produced.
3.44. Inject 4 *mgm. nicotin.*
3.51. Stim. sy.; all the usual effects produced.
3.55. Inject 4 *mgm. nicotin.*
3.59. Stim. sy., 10 secs., $c = 9$; nictitating membrane withdrawn a little, no other effect.
4.0½. Stim. sy., 10 secs., $c = 8$; nictitating membrane slowly drawn back, no other effect.
4.1¼. Stim. sy., 5 secs., $c = 8$; same effect, and pupil slightly dilated.
4.2. Stim. sy., 5 secs., $c = 8$; as before, and slight contraction of lower eyelid and mouth observed.
4.4. Stim. sy., 60 secs., $c = 8$; little, if any, immediate effect on tongue, but a slight after-flush.
4.6. Stim. sy., 60 secs., $c = 8$; mouth chiefly observed, a little paling of tongue and lips at first, changing to slight flushing at end of stimulation; pupil, as before, shows slight dilation only.

In this experiment, the dilation of the pupil was noticed before the opening of the eye, but, in some other cases, we have not been able to satisfy ourselves that this occurred. And it is possible that the position of the eyelids, whether nearly closed, or half-open, as they usually are after nicotin, influences the result. Similarly, we have not been able to assure ourselves at what time, in relation to the dilation of the pupil, a paling of the conjunctiva, and a paling of the mucous membrane of the mouth, occurs. We are inclined to place them in order of ease of paralysis, as follows: paling of mouth, paling of conjunctiva, opening of eyelids, dilation of pupil. We have not made a comparison between the ease of paralysis of the sympathetic effect upon the withdrawal of the nictitating membrane and the constriction of the vessels of the ear.

The Dog.—When nicotin, even in large amount, is injected into a vein in the dog, there is a rapid recovery of the effect of stimulating the cervical sympathetic* as regards the constriction of the small arteries of the salivary glands, the dilation of the pupil, and the secretion of saliva. We have generally observed a slight difference in the time of recovery of these three effects, in the order in which they are mentioned above, but there are special difficulties in the way of determining the exact time when stimulation of the nerve begins

* *Cf.* Langley, 'Journ. of Physiol.,' vol. 11, 1889, p. 123.

to be effective on the constriction of the vessels of the ear and on the secretion of saliva.

The other effects of stimulating the cervical sympathetic are, however, more easily suppressed by nicotin. The one most readily abolished is the flushing of the lips. With regard to the relative ease of paralysis of the movements of the eye, eyelids, nictitating membrane, and pallor of the mucous membrane of the mouth, we have made a few experiments only, so that we cannot speak of them with much confidence. The order, so far as our experiments go (*cf.* Exp. VI), is movement of the eyelids, movement of the nictitating membrane, pallor of the lips.

Experiment VII.

Dog (C. p. 11). Morphia. Chloroform and ether.

Left sympathetic separated from vagus for about an inch below superior cervical ganglion, ligatured, and cut. With secondary coil at 10 ($c = 10$), the shocks are distinctly felt on the tongue, but are not strong; with secondary coil at 6 ($c = 6$), the shocks are strong to the tongue. Stimulation of sympathetic with $c = 10$ causes flushing of lips and gums.

1.26. Inject into femoral vein 50 mgm. nicotin.

1.29. Stim. sy., $c = 10$, 20 secs.; no effect on eye or lips.

1.34. Stim. sy., $c = 6$, 30 secs.; no effect on eye or lips.

1.36. Stim. sy., $c = 8$, 60 secs.; lips slowly become pale on both sides, but this may be the after-effect of nicotin; no other change. The eye quickly shuts on touching the skin near it.

1.43. Stim. sy., $c = 8$, 60 secs.; pupil dilates—it was large before stimulation.

1.52. Stim. sy., $c = 8$, 60 secs.; pupil dilates readily, no other change observed; on left side lips are very pale, and the nictitating membrane is partially drawn back; on right side lips are pinkish, and nictitating membrane is $\frac{1}{3}$ to $\frac{1}{2}$ way over the eye.

2.10. Stim. sy., $c = 8$, 60 secs.; edges of lips become paler.

2.16. Stim. sy., $c = 8$, 60 secs.; momentary movement of nictitating membrane.

2.35. Stim. sy., $c = 12$, 30 secs.; eye opens.

2.37. Stim. sy., $c = 7$, 30 secs.; lips slightly flush for 10 to 15 secs., then become pale.

An interesting result is often obtained by stimulating the sympathetic after a rather larger dose of nicotin; in this case, the pupil is rather large, the eye is turned forwards, and the eye is open, but not widely; stimulation of the sympathetic then causes the eyelids slowly to approach one another, *i.e.*, the eye, instead of opening, becomes more closed. The movement is chiefly in the lower eyelid. On ceasing the stimulation the eye gradually opens to its previous extent. The closing of the eye on stimulating the sympathetic occurs at a time when the stimulation still produces dilation of the pupil and secretion of saliva. It will be remembered that Rogowicz* observed occasionally a similar closing of the eye in the dog when the sym-

* 'Archiv f. d. ges. Physiol.' (Pflüger), vol. 36, 1885, p. 7.

pathetic was stimulated several days after section of the facial nerve. He attributed it to a contraction of the orbicularis palpebrarum. It is possible that the sympathetic has nerve fibres stimulation of which causes closure of the eye, as well as fibres stimulation of which causes opening of the eye, and that the nerve cells in the superior cervical ganglion connected with the former are less easily paralysed by nicotin; but there is no decisive evidence of this, and the closure obtained may be explained in other ways.

Summary.

Generally speaking, stimulation of the cervical sympathetic in the dog with minimal effective shocks causes pallor in the lips and gums; with weak to moderately strong shocks, primary pallor followed by flushing; with strong shocks, as shown by Dastre and Morat, primary flushing, but the extent and duration of the primary effect and of the secondary effect, if there is any, varies in different dogs.

In the rabbit and cat, stimulation of the cervical sympathetic always causes, as shown by Bochefontaine and Vulpian, primary pallor in the lips and gums, and the after-flush is not great. The pallor we find is bilateral; the degree of the pallor on the opposite side to that stimulated varies in individual cases, and can be seen on the tongue, as well as on the lips and gums.

On injecting nicotin into a vein, certain of the normally occurring effects of stimulating the cervical sympathetic cease before the others, *i.e.*, since all the effects can still be produced by stimulating the fibres running from the superior cervical ganglion, the nerve cells in the ganglion, which are connected with different classes of nerve fibres, are paralysed with different degrees of ease by nicotin.

Arranging the various effects in the order of ease of paralysis, we have:—

Rabbit.

(1.) Withdrawal of the nictitating membrane.
(2.) Opening of eye.
{(3.) Dilation of pupil.
}(4.) Constriction of blood-vessels of conjunctiva.
{(5.) Constriction of blood-vessels of lips and gums.
}(6.) Constriction of blood-vessels of ear.

In one or two cases, no difference in the ease of paralysis between the bracketed actions has been observed.

Cat.

(1.) Secretion from sub-maxillary gland.
(1) {(2.) Opening of eye.
(3.) Dilation of pupil.
(4.) Constriction of blood-vessels of conjunctiva.
(5.) Constriction of blood-vessels of mouth.

(2) { (6.) Constriction of blood-vessels of ear.
(7.) Withdrawal of nictitating membrane.

(1) Constant differences between these have not been observed.

(2) These have not been directly compared, but in separate experiments each has been obtained when (1.) to (5.) were no longer seen.

Dog.

(1) { (1.) Dilation of arteries of bucco-facial region.
(2.) Movements of eye and opening of eyelids.
(3.) Withdrawal of nictitating membrane.
(4.) Constriction of arteries of gums and lips.
(5.) Dilation of pupil.
(6.) Secretion from sub-maxillary gland.
(7.) Constriction of blood-vessels of the sub-maxillary gland.

(1) Differences between these have not always been observed.

At a certain stage of nicotin poisoning, when stimulation of the sympathetic does not cause withdrawal of the nictitating membrane, but does cause dilation of the pupil, a partial *closing* of the eye is obtained by stimulating the sympathetic.

It will be noticed that in each animal nicotin abolishes most of the effects of stimulating the cervical sympathetic at very nearly the same time. With regard to these, we think that there is only a *primâ facie* case for regarding the differences observed as due to an unequal paralysis of the nerve cells of the superior cervical ganglion, for it is possible that the differences may be due to an unequal tonic stimulation reaching the parts by nerve fibres other than the sympathetic. But the greater differences observed, for instance, between the secretion of saliva and the dilation of the pupil in the cat, the flushing of the lips and the constriction of the vessels of the submaxillary gland in the dog, we do not think can be due to such a cause, and we attribute them to an unequal paralysing action of nicotin upon the nerve cells of the superior cervical ganglion.

The Society then adjourned over the Easter Recess to Thursday, April 17th.

Presents, March 27, 1890.

Transactions.

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